colliding with the one that had broken through the capsular wall. Each collision forced it out a little farther into the sea water until after three or four such contacts it burst out of the capsule and swam about freely. The veliger was literally hurled from the capsule as if forced out by some internal pressure. As soon as the first one left, a second took its place in the opening and was blown or forced out into the surrounding sea water. The internal pressure within the capsule seemed to grow weaker as each veliger left the capsule until finally only one remained swimming about inside. No substance was observed to be extruded from the capsule with the veligers. It is entirely possible that osmotic pressure increases within the capsule as the veligers develop and that this is the force that propels them through the opening in the capsular wall and into the surrounding sea water.

THE AMERICAN SPECIES OF *VIVIPARUS*

By CALVIN GOODRICH

Mr. T. Van Hyning of the Florida State Museum has recently submitted an accumulation of Floridian *Viviparus* for comparison with examples of the genus in the Bryant Walker Collection. It was made clear very quickly that a good deal of basic information had first to be acquired. So all the available material having its source within the United States was examined, shell by shell. The literature on the subject was read. The geographical distribution of the several species was brought into such order as was possible. Since the study developed facts which appear not to have been published, or if so in scattered form and perfunctorily, I am venturing to set forth the findings.

The genus *Viviparus* illustrates what may be a natural law governing molluscan nomenclature, namely, that the more simple the shells of a group may be, the fewer and the least definite its characters and the more difficult to describe lucidly, then the heavier burden of specific names the group is compelled to carry. In this matter, *Viviparus* lags a great way behind Pleuroceridae or perhaps the French Anodontinae, but it is probably abreast of some of the genera of Zonitidae and even with the currently expanding *Cerion*. Reeve recognized about seventy species of

Paludina which in his day was an Island of Crete on which species parachuted in flocks. It included *Viviparus, Campeloma, Tulotoma, Lioplax* and other genera that now are differentiated one from another. Kobelt undertook to treat of *Viviparus* alone, but left the American forms under *Paludina.* Notwithstanding limitations he established, his species and subspecies of *Viviparus* ran to 259. On the assumption that anything geologically old must be extinct, American paleontology has devised about thirty names, permitting only *V. georgianus* of the Florida Pliocene to survive into recent times. There have been additions since Kobelt, some cleaving and splitting, but hardly any recognition of the truth that *Viviparus,* like most fresh water mollusks, is inconstant of shape and pigmentation.

Generic characters, the same as specific characters, are variable. Embryo shells of western forms that have been seen are thin, whitish, transparent, but in specimens of a Florida form that Van Hyning sent which contained the animal parts the embryos ranged in color from yellowish white just after development from the egg to dark brown when the shell is ready for discharge. The young shell is so much broader than high that Say (1829) did not recognize it as merely a juvenile and gave that of *V. intertextus* the name of *Paludina transversa.*

The embryo has from two or three to a dozen or more lines of epidermal striations, raised into very fine hairs. In the uncleaned lot of Van Hyning shells were numbers of adults which retained the lirations, but as any ordinary brushing will remove the bristles such examples are probably very rare in collections. Binney (1865) in Fig. 54 has illustrated a shell of the kind, and Say in his description of *intertextus* noted that his specimens had "minute, very numerous, obsolete revolving, deciduous lines." In the instance of Reeve's *Paludina ciliata,* of Siam, the raised parts of the lines are, as Reeve put it, "eye-lashed." Wetherby (1876) found that *Tulotoma coosaensis* had a "coating of long spines or hairs, arranged in spiral rows around the whorls." Probably no cabinet specimen of *coosaensis* still has these "spines." So what is not simply a generic character, but also a family one, may be so evanescent as to escape general attention.

The periphery of the embryo is rounded, roundly angled or

sharply angled; in *V. viviparus* it is said to be carinate. Possibly mechanical pressure in the marsupium determines the form of the keel. As growth proceeds, the shell alters its configuration rapidly from broad and depressed to conic or globose. The adult shell of American *Viviparus* is commonly short-spired. It has a large body whorl, a correspondingly large aperture and four equidistant bands of pigment, where banding exists, that are occasionally decreased or increased in number. The whorls do not, seemingly, exceed six or six and a half, although the count in some foreign species runs to seven. The green ground color usually mentioned in descriptions fades in old specimens to brown or dark yellow and, bleached by sun and rain on lake beaches, this may become almost white. The oldest individuals of a Georgia lot were black as were shells of about three whorls which came from the Santa Fe River of Florida. Mr. Van Hyning directed my attention to the fact that lake forms of the southeast are "much smaller than the ones from the rivers." Specimens of *contectoides* from two lakes of Indiana are of about the same size as material from Indiana streams. The operculum does not appear to vary as between species. It is thin, concentric, showing many rests or pauses, the later ones rougher than the earlier ones.

Viviparus contectoides Binney, 1865. The mollusk is from five to six whorls in size, ordinarily thin, deeply sutured. The four bands when present are usually well marked, conspicuous. The umbilical perforation is a mere chink or is entirely covered over by the columellar fold. Three embryos have an index of obesity averaging 107.1, showing the excess of diameter over altitude in the very young. Four shells from a lake of Putnam County, Illinois, lacking about a whorl of maturity, have an obesity index of 95.2. Because of the common erosion of apices in adults, comparison of diameter with altitude in such specimens could be made only by measuring the height of the last three whorls. The range of indexes of thirteen lots, measured in this way, is from 85.3 to 89.9. This can scarcely be thought a wide variation in degree of globosity, but in general appearance there is considerable variation as between colonies of different localities. It has been noticeable at the same time that members of a given colony of the genus are very much alike. In other words, approach to

equilibrium is reached in each locality, and this applies to form, proportions, pigmentation of epidermis and banding.

Van Cleave and Richey (1936) noted that the medians of the radula of this species have commonly 5–1–5 denticles, with a range of 4–6—1—6–4. This is a lower average denticle count than was found in other species the radulae of which were studied.

The distribution of *contectoides* is from New York to West Florida, South Carolina to Arkansas (F. C. Baker, 1928). The Binney citation (1865) from Michigan may be ignored.

Viviparus contectoides impolitus Pilsbry, 1916. The shell is described as "rough, with irregular growth lines, often somewhat malleated." As these are external characters, the mollusk might, simply on these points, be dismissed as an ecological form. Yet it occurs in several localities of an area of North Alabama which has a number of molluscan oddities and might very well have developed specialized anatomical characteristics correlated with those of the exterior, all through prolonged existence in springs and spring branches. The ratio of diameter to altitude in *impolitus* is about the same as in typical *contectoides*. The last whorl is strongly shouldered and in some specimens its slope does not form a continuous line with the earlier whorls.

Viviparus contectoides goodrichi Archer, 1933. The index of obesity is from 80.1 to 84.8. That is, it has a greater average altitude compared with diameter than *contectoides* has. Of seventy specimens, thirty-seven, or 52.8 per cent, were wanting the revolving color bands. The shell is the common *Viviparus* of Chipola River, western Florida, some of its tributaries and the neighboring Choctawhatches River. Shortly after the subspecies was named, Mr. O. C. Van Hyning sent me examples of all the mollusca of the type stream. It was noticeable that the surface occupants were all larger than was common to their species whereas the bottom inhabitants were of normal size. It seemed at the time reasonable to conclude that the surface of the stream was carrying more food than were lower waters, and that this richness was reflected in the greater growth of the top dwellers. Such a reaction has been observed elsewhere. However, *goodrichi* is distributed over a fairly wide area and has there retained its peculiarities, and short of further study or experiment should be considered a distinct race.

Viviparus contectoides form *limi* (Pilsbry), 1918, replacing *V. contectoides compactus* Pilsbry, 1916, preoccupied. The shell is dwarfed, somewhat compressed, imperforate. It has been taken at widely separated localities in Georgia and Florida. It appears to be an ecological form that might turn up anywhere within the area of distribution of *contectoides*.

Viviparus troostianus (Lea), 1844. I am following Call (1894) as to the identity of this species. In shape, this shell is very much like *contectoides*, but of about half its size. Also like it, it has four clearly defined bands. It resembles *intertextus* of northern waters in being umbilicated. It is known to occur in Stone's and Harpeth rivers of the Cumberland River in Tennessee; Spring Creek, the discharge of the big spring at Tuscumbia, Colbert County, Alabama, emptying into the Tennessee River. Such shells that have been seen are uniform of configuration, umbilication and color.

Viviparus intertextus (Say), 1829. The nine embryos that have been examined differ from those of *contectoides* in being more depressed, and this bears a relationship with the adult form of the species which is low-spired, decidedly globose. The full measurements of one Louisiana specimen is 25.50 mm. altitude, 25.50 mm. diameter, of a Mobile, Alabama, example, 26 mm. by 26 mm. Southern specimens, measured as were *contectoides*, have an obesity index of 95.3. The shells seen are dark, thin, large of aperture; the whorls shouldered. The greatest number of whorls is five. There are no color bands. The umbilicus is closed in all available for examination save two or three specimens. This form has been taken as far north as Henry County, Missouri.

Viviparus intertextus illinoisensis F. C. Baker, 1928. The subspecies was erected mainly upon its being umbilicate in the majority of instances. All shells seen that came from north of the Ohio River fall within the description. Of sixteen specimens from woods pools near Reelfoot Lake, west Tennessee, nine could be called *illinoisensis*, the others more truly *intertextus*. Material from the Illinois River has an obesity index of 107.5, that from White Bear Lake, Minnesota, 95.7. The number of whorls of the subspecies does not seem to exceed four and a half. Banding is

in course of obsoleseence. There are indefinite indications that small stream forms of this shell are of higher spire than those of larger streams. *Illinoisensis* occurs in the Upper Mississippi River, in Wisconsin and Illinois, and in the drainage of the Wabash River in Indiana. Perhaps certain lots from Kentucky belong here.

Viviparus subpurpureus (Say), 1829. The species is of two forms, one markedly conic, the other in which the body whorl is nearly as ventricose as is that of *intertextus*. The index of obesity of the conic form is 77.6 to 86.2; of the more globose aspect, 86.0 to 90.6. So far as may be assumed from specimens at hand, the globose form is of the larger streams, the Mississippi, Ohio and Wabash rivers. The full measurements of the two largest shells seen are:

Big Creek, Posey County, Indiana, six whorls Alt. 35.50, dia. 23.75.

Wabash River, New Harmony, Indiana, five and a half whorls: Alt. 30, dia. 24 mm.

The whorls are more flattened than in other species, the aperture of smaller relative size. The spire of the embryo is somewhat elevated. F. C. Baker (1928) directs attention to the odd bulging of the penultimate whorl, plainest when the aperture is turned away from the observer. In a few lots, the shells of which seemed depauperate, this characteristic was absent. The purplish tinge noted by Say has faded in cabinet examples. As in *intertextus,* banding is in course of disappearance. The umbilicus is usually covered by the columellar fold, but in occasional specimens a small chink is left.

Viviparus subpurpureus texanus (Tryon), 1862. F. C. Baker (1928) has resurrected this mollusk from the synonymy on the strength of its being "a much narrower shell which occurs from Missouri to Texas, Louisiana and Mississippi." Unless the following form is *texanus* I have seen no specimens of it.

Viviparus subpurpureus form *halcanus* (Lea), 1847. Lea says of his mollusks that they show "a disposition in most of the specimens to a compression below the sutures," which may be condensed to "flat-whorled." This is characteristic of shells from Caddo Lake, Louisiana, and Texas, all of which are small,

rather thin and without revolving bands. The index of obesity is 85.4 which is within the range of the northern conic forms of typical *subpurpureus*. One shell alone of those observed had the swollen penultimate whorl. At best, I believe, *haleanus* is only a variant. Call's opinion of it (1894) may be gathered from the fact that he cites typical *subpurpureus* from Caddo Lake, and ignores the name *haleanus*.

Viviparus georgianus (Lea), 1937. The Lea specimens were assigned to Darien, Georgia, a place-name that among naturalists of the early nineteenth century loosely included the Altamaha River and its bayous, St. Simon Island and probably even Sidney Lanier's "Marshes of Glynn." *V. waltonii* Tryon of St. John's River, Florida, is virtually identical with the Lea shells, as is also his varietal *fasciatus*. The species, inclusive of its several forms, is large or small, thick or of nearly paper thinness, conic or globose, banded or without bands, the whorls decidedly convex or somewhat flattened—greatly varied as between colonies, but little so within them. In a circumscribed area of the Lake George region, specimens from Hitchen's Creek have the conic configuration which Pilsbry named *altior*, shells from Juniper Creek take the globose form to which the name *walkeri* has been given, and at least one locality has shells corresponding to the depauperate *warcanus*.

The obesity indexes of *georgianus* of what can be termed the usual or common St. John's River phase are from 79.8, Lake Okeechobee, to 86.1, Lake Teala Apopka, but most of the Van Hyning lots are in the narrower range of 84 to 86.

The umbilicus is covered with the columellar fold in most instances. Of fifteen lots of the Van Hyning collection, seven have dark revolving bands in an epidermal ground color only slightly lighter; five have the same dark bands contrasting with a ground color of yellow or yellowish-brown, and three are yellowish, the bands so faded that it would seem the pigment glands lacked material for proper secretion. In several of the lots are individuals entirely without bands, the epidermis approaching albinism.

A curious form is a light-colored race from the Suwanee River at Fannin Springs, Levy County, Florida. Van Hyning's label

records that it was "found clinging to the under side of rocks." Thirty-two per cent of 76 specimens have color bands, none of them conspicuous. Rest marks make contrasting black axial lines against a whitish-yellow ground color. Sixteen distinct varices were counted in one shell. The obesity index of the seventeen largest specimens is 83.6, which is that of typical *georgianus*. Another lot, labelled as from the same locality, has an index of 88.3, and resembles the form *walkeri*. It would appear that within a short reach of the Suwanee River are differing ecological conditions reacting differently on the same mollusean species.

The center of population of *georgianus* is eastern and central Florida. Binney reports the species as occurring in South Carolina. *Vivipara haldemaniana* "Shuttleworth," Frauenfeld, 1862, type locality, Black Creek, Florida, is probably identical with *georgianus*, 1837.

Viviparus georgianus form *altior* (Pilsbry), 1892. The original lot was from an Indian refuse heap. The five or six whorls are loosely coiled, a little flattened. The oldest specimens have the distorted body whorl which, at least in the Pleuroceridae and probably so in *Viviparus*, is a symptom of senility. Dall (1892) spoke of others of this same finding as "remarkable malformations," and said they were "due without doubt to the direct physiological action of some obnoxious substance, such as salt, sulphur, etc., in the water in which they lived." The "obnoxious substance" may quite as likely have developed in the organisms themselves just as diseases of old age do in mammals. Inasmuch as some of the individuals taken from the kitchen midden are neither distorted nor malformed there seems no sound reason for discarding *altior* altogether although, considering its close geographical connection with more typical *georgianus*, it does, to all seeming, belong to a category of less importance than subspecies. The average obesity index of twelve specimens is 77.1, showing that in spite of a body whorl of large diameter, the altitude is unusually high. Bands may be seen by transmitted light. Shells resembling *altior* are in the Walker collection from Lake Monroe and Jessup, Orange County, Florida, and in Mr. Van Hyning's from Lake Ashley, Volusia County.

Viviparus georgianus form *limnothauma* (Pilsbry), 1895. The

whorls of the types are "much swollen around the upper part, sloping below, giving a shouldered appearance." The shells were found in the same refuse pile as *altior*. Pilsbry reported that others were collected living in Lake George.

Viviparus georgianus form *walkeri* (Pilsbry and Johnson), 1912. This is a globose form corresponding to *V. intertextus* of the Mississippi Valley, but more closely related to *georgianus* than *intertextus* is to any other species of its region. Paratypes are thin, rather rough, the bands almost merging into the dark ground color. The obesity index of ten topotypes averages 95.2. Other lots nearly as globose are from Ocklawha River, Marion County, and a branch of Peace River, Polk County, Florida. With some hesitancy, larger and heavier shells of the Suwannee drainage, of which Sante Fe and New rivers are a part, are placed under *walkeri,* and this mainly on the ratio of diameter to height. A still larger, thicker, more shouldered *Viviparus* occupies Silver Springs, Marion County. Two separate lots of fifteen shells each gave an average index of obesity of 89.7 and 90.9. The full measurements of five Silver Springs shells of the Van Hyning collection averaged 27.75 mm. altitude, 24.50 mm. diameter. Out of forty-nine specimens examined, twenty-two have the usual four bands; ten have lost one of these bands; six have lost two, and eleven are without bands.

Viviparus georgianus form *wareanus* (Shuttleworth), 1852. The shells, taken in Lake Ware, East Florida, reached Shuttleworth through Rugel, and Rugel gave specimens to Mrs. Andrews, whose collection came into the possession of Bryant Walker. These mollusks are thin, brownish, without bands; the umbilicus is merely a chink. The index of obesity is 85.7, which is close to that of *georgianus* of Lake Okeechobee. Similar forms are from Reedy Lake, Polk County; parts of Lake George and a place named Upson that is not listed in the United States Postal Guide. The only material in the Van Hyning lots that might be called *wareanus* is from Wauberg Lake, Alachua County, Florida. The mollusk in my opinion is a depauperate one.

The position of the following is uncertain:

Blue Creek, Early County, and Oseewichee Springs, south of Abbeville, Wilcox County, Georgia. The specimens are rather

large for southeastern *Viviparus*. They are heavy, shouldered; the aperture is more ovate than circular. The body whorl is a little flattened. Whorls, five and a half. Each shell has four well-marked color bands. The two lots have characteristics both of *contectoides* and *georgianus*. It may be of significance that they are on, or near, the dividing line between those two species.

Lake Waccamaw, Columbus County, North Carolina. Twenty-two specimens. Umbilicus covered except in seven in which the columellar fold does not completely extend over the opening. Obesity index, 97. No bands. The shells have been called *V. intertextus*, but their location is so far east of the range of that species and so much nearer to the area of *georgianus* that it seems probable the mollusks have an affinity with Florida forms more than, superficially, they appear to have.

Blue Springs Run, 3 miles east of Marianna, Jackson County, Florida. Not greatly different in shape from the St. John's River forms. The ground color corresponds to the Danube Green of Ridgway's "Color Standards." Counting capillary lines with bands, one specimen has eight of these revolving pigmentations. Through coalescence of bands, one shell has three, one only two. There is, besides, the common four-band formula. The colony is outside the region that may be termed *georgianus'* and in that of *contectoides goodrichi*.

On the bases of information available, it can be said that *Viviparus* of the United States has a fairly symmetrical geographical pattern. The one serious flaw in it is that isolated occurrence of the genus in North Carolina, and this defect or imperfection may in time be removed by a more thorough understanding of specific relationships.

References

Baker, F. C., The Fresh Water Mollusca of Wisconsin, 1928, Pt. 1, pp. 31–44.

Binney, W. G., Land and Fresh-Water Shells of North America, 1865, Pt. 3, pp. 16–32.

Call, R. E., On the Geographic and Hysometric Distribution of North American Viviparidae, Amer. Journ. of Science, 48, 1894, pp. 132–141.

Dall, W. H., Contributions to the Tertiary Fauna of Florida,

Trans. Wagner Free Institute of Science, 3, Pt. 1, 1890, pp. 332–335.

HENDERSON, JUNIUS, Fossil Non-Marine Mollusca of North America, Geol. Soc. of America Special Papers, No. 3, 1935, pp. 165–177.

KOBELT-SCHWANHEIM, W., Die Gattung Paludina Lam. (Vivipara Montfort), Systematisches Conchylien-Cabinet von Martini und Chemnitz, Pt. 21a, 1909, pp. 97–430, Pl. 15–77.

REEVE, L. A., Monograph of the Genus Paludina, 1863.

VAN CLEAVE, HARLEY J., and EMILY MCDAVID RICHEY, Studies on the Radula in Snails of the Genus *Viviparus*, Trans. Amer. Microscopical Soc., 55, 1936, pp. 223–229.

WETHERBY, A. G., Review of the Genus *Tulotoma*, with Remarks on the Geographical Distribution of the North American *Viviparidae*, Quar. Journ. Conchol., 1, 1876, pp. 207–215.

OLIVELLA PYCNA

BY D. S. AND E. W. GIFFORD

On July 9, 1941, we collected seven living examples of *Olivella pycna*[1] on the beach at Cresent City, Del Norte County, California. The following day we took another at Port Orford, Curry County, Oregon, but failed on the 11th to find any at Trinidad Head, Humboldt County, California.

The University of California Museum of Anthropology possesses 885 archeological examples of this species from various ancient Indian mounds in Central California, as follows: from Kern County, 1; from the Delta region of San Joaquin, Sacramento, and Contra Costa Counties, 647; from Napa County, 1; from San Francisco Bay shores (Alameda and Santa Clara Counties), 229; from the shores of Drake's Bay and Tomales Bay, Marin County, 7.

Bolinas, Marin County, is the type locality for *Olivella pycna*. There it was dredged from 3 to 4 fathoms depth. Mr. Allyn G. Smith, who kindly checked our identification, has a series dredged near Hog Island, Tomales Bay, from a depth of 5 fathoms. The University of California Department of Zoology has several taken littorally in Tomales Bay. Messrs. Tom and John Q. Burch have kindly supplied us with littoral specimens from Morro Bay, San

[1] S. Stillman Berry, An Undescribed Californian Olivella, Proc. Malacological Society of London, vol. 21, pp. 262–265, 1935.